Monitoring and assessing macroinvertebrates and stream habitat conditions in the Ashland Watershed

Emily Ho'o Kamalani Long
Department of Environmental Studies
Southern Oregon University
Ashland, OR, USA

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Abstract:

Analyzing macroinvertebrate communities across numerous streams in a single watershed provides a cost-effective means of assessing stream conditions that can be evaluated over time and across sites. The purpose of this research is to provide valuable information about possible changes in the Ashland watershed sue to the effects of the Ashland Forest Resiliency Stewardship project (AFR). Canopy closure showed no differences (df=3, P-value>0.25) among sites, therefore we can expect sparse canopy cover to not be an issue as a source of biotic stress. Large in-stream woody debris exhibited significant differences between South Section 20 and West Fork (df=3, P-value<0.033). Residual Pool depth showed differences among sites (df=3, P-value<0.00), but no significant difference between the East and West forks. Substrate had significant differences between habitats (no, adequate, stable). In addition there is a significant interaction between each site and the habitat. The HBI differs between the East Fork and the West Fork (df=3, P-value<0.028).

Keywords: *Aquatic ecology, habitat, macroinvertebrates, watershed, Ashland, Oregon.*

Introduction:

Monitoring the biological community of various streams provides a cost-effective means of assessing stream health, particularly when at the watershed scale. Macroinvertebrates are easy to collect, fairly stationary and are responsive to human disturbance. Additionally, the relative sensitivity or tolerance of many macroinvertebrates is well known (Water Quality Interagency, 1998). Generally, they provide an applied approach to understanding and measuring stream quality and health.

The Ashland Forest Resiliency Stewardship Project (AFRSP) consists of multi-level, multi-party monitoring implementation to address concerns through changes in important indicators and provide information for adaptive management (Metlen et. al, 2013). To address sediment effects of AFR activities two techniques were measured; (1) Wolman pebble count; a direct measure of sediment size in the streams, and (2) Pool depth, a measure of habitat availability directly impacted by accumulated sediments. Additional parameters that reflect potential impacts on aquatic habitat include (1) Canopy closure, (2) In-stream large wood, and (3) aquatic macroinvertebrate assemblages. All parameters chosen for analysis are presented in Table 1. Methods for aquatic monitoring are not concerned in measuring the effects of AFR treatments but to gather a baseline of general trends over time. Therefore the purpose of this research is to examine differences in important indicators across all streams. Aspects of this issue of interest include; (1) How do habitats differ across the four streams?, (2)Do the H.B.I (Hilsenhof biotic index) differ among the four streams?, and (3) Which streams differ from one another?

Table 1. Displays parameters, rationale, and methods of water quality monitoring (Metlen et. al, 2013).

Parameter	Purpose	Method	Reference
Aquatic Macroinvertebrates	Sensitive to variety of short and long-term stressors	EPA Targeted Riffle	USEPA, 2001
Canopy Closure	Changes in riparian vegetative closure	Densiometer	Lemmon, 1956
In-stream Large Woody debris	Large-scale changes in stream structure	Direct Counts	Reid, pers. com.
Residual Pool Depth	Measure of slow water habitat, reduced with increasing sedimentation	Direct measurement at riffle crest	Reid, pers. com.
Wolman Pebble Counts	Direct Count of substrate size and sedimentation	Sample Counts	Bevenger and King 1995

Data and Methods:

Study sites were selected to incorporate sites with historic data and concurrent USFS monitoring activities (Table 2), in addition locations most likely to exhibit effects from AFR treatment based on geographic position (Metlen, et al. 2013). At all sites the reach lengths totaled 150 meters to adequately sample stream geomorphology and incorporate all microhabitat variation. Most sampling programs establish a lower minimum reach length of 150 meters (Kaufmannn et al. 1998).

Table 2. Sites being monitored for water quality impacts of AFR activities on Ashland Creek. Density management (DM) and surface and ladder fuel treatment (SL) was conducted on only a percentage on each reach's basin (Metlen et. al, 2013).

Reach	Status	Elev.(m)	Watershed size (acres)	DM Treated	SL Treated
East Fork	Historic	887	5193	3%	9%
Reeder Gulch	New	883	472	13%	19%
South Section 20	New	856	171	3%	4%
West Fork	Historic	899	6756	1%	2%

Benthic macroinvertebrates were collected using the Target Riffle (TR) habitat techniques from the USEPA EMAP (Environmental Monitoring and Assessment Program) (USEPA, 2001). A 1 ft wide kicknet or Surber (500µm mesh) was used to collect eight ft^2 of riffle habitat that is composited into a single sample (total area=0.744 m^2). At each subsamples, substrate directly up-stream of the net is moved and scrubbed, causing displaced macroinvertebrates to flow into the collection net. Collection has been done annually by SOU students, and initiated and processed by Dr. Peter Schroeder (SOU) with further analyses by the Bureau of Land Management National Aquatic Monitoring Center (Metlen et. al, 2013).

To assess the stream condition using macroinvertebrate communities as the primary indicator, a Level III protocol was evaluated to provide a sensitive measure of stream condition. There are four classes of stream condition that can be determined: no disturbance, slight disturbance, significant disturbance, and severe disturbance.

Riparian canopy is measured at a single point in the reach using a spherical densitometer (Table 1). The densitometer is held level at breast height (~4 ft) and the number of gridded intersections with vegetation obscuring the point are counted and recorded. Upstream, left bank, right bank, and downstream are the four measurements and then averaged into a single value for the reach (Lemmon, 1956). The values are calculated as a percent coverage by dividing the average points by the total possible points (Metlen et. al, 2013).

Woody debris counts are performed by walking upstream from the starting coordinates and counting all large dead wood in the active stream channel in three combined size classes. Changes and trends in overall volume are tracked points (Metlen et. al, 2013). Using a meter stick to measure stream depth at selected points, pool depth is measured progressing upstream. Where a pool is observed, the field observer measured the maximum depth, and height of the pool tail crest. The difference between maximum depth and tail crest is the *Residual Pool depth,* which represents the pool depth if flow was to cease (Metlen et. al, 2013).

Pebble counts are performed by "zig-zagging" up the stream channel and touching a substrate over the toe of the observer's wader approximately every seven ft (Bevenger and King 1995). Then a total of 100 particles were recorded using the modified Wentworth scale. Particle counts can then be used to track the small sediments (e.g. <2mm; etc.) and in addition the mean substrate size to track the potential for increased cumulative sediment loads during AFR treatment points (Metlen et. al, 2013). Additionally I compiled the substrate classes into three hyporheic zones: no habitat, adequate habitat, and stable habitat to consolidate all the substrate classes that made the most biological sense.

To examine differences of habitat conditions using the parameters listed in Table 1, for variables; canopy closure, in-stream woody debris, and residual pool depth one-way ANOVAs were used to test differences among each variable and the four sites. To examine the tolerance or sensitivity of the macroinvertebrate assemblages the HBI (*Hilsenhof Biotic Index*) was calculated and those values were analyzed for variance across sites. This is an index of a taxa's sensitivity to organic enrichment that typically occurs as a consequence of excessive nutrient inputs. Values for individual taxa range from 1 to 10, low scores indicate high sensitivity (found in waters with low organic enrichment) and high scores indicate low sensitivity (tolerant of waters with high organic enrichment). For substrate I ran an analysis of variance for substrate with habitat fixed as no, adequate, and stable habitat across all four sites. All inferential analyses were conducted with an $\alpha=0.05$.

Results and Discussion:

Canopy closure was high, the total mean was 92 and ranged from a low of 86 to a high of 99 (Table 3). This high volume of canopy can cause lower inputs of solar radiation, which in return can affect macroinvertebrate communities. Figure 1 shows the box plots of canopy closure and the values are similar in comparison. There were no significant differences in canopy cover among sites.

Table 3 Average canopy closure (%) and standard deviation across years at 4 tributaries to Ashland Creek.

	Mean	Std. Deviation	Min.	Max.
East Fork	89.3	3.0	86	92
Reeder Gulch	91.0	4.5	86	95
South Section 20	94.6	3.7	92	99
West Fork	94.3	2.0	92	96
Total	92.3	3.7	86	99

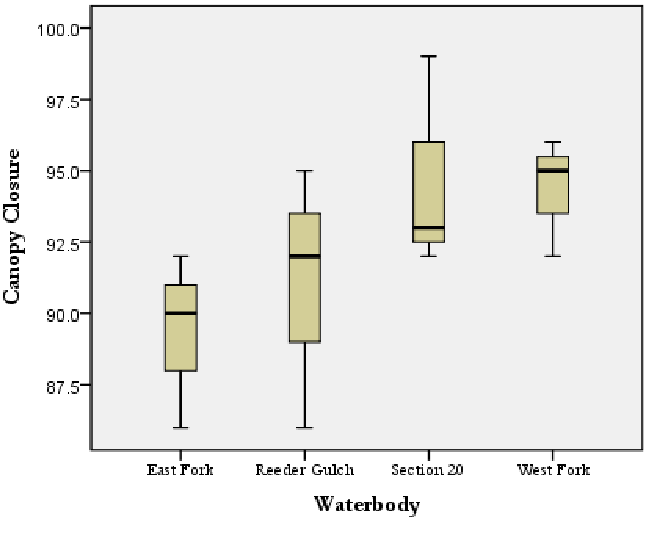

Figure 1 Displays the box plots for Canopy closure for the three years across the four streams

An ANOVA procedure finds that residual pool depth and in-stream woody debris are significantly different (Table 4). A Tukey post hoc analysis reveals that residual pool depth is statistically significant between all sites except there was no difference between East and West Fork. Figure 1 shows the mean residual pool depth of all years across all sites. The graph depicts the differences across all sites. A Tukey post hoc analysis reveals that in-stream woody debris had significant differences between South Section 20 and West Fork. Figure 2 displays the box plots of the in-stream woody debris for all years across all four sites. Figure 3 shows the major differences between South Section 20 and West Fork. Additionally, Section 20 and West Fork differ by residual pool depth and these habitat conditions perhaps can impact the biological macroinvertebrate assemblages.

Table 4 ANOVA table displaying the variables examined F-test values, and p-values.

Variable	Type of Test	F-Test	P-Value
Canopy Closure	ANOVA	1.651	>0.254
In-stream Woody debris	ANOVA	4.863	<0.033
Residual Pool Depth	ANOVA	98.779	<0.000

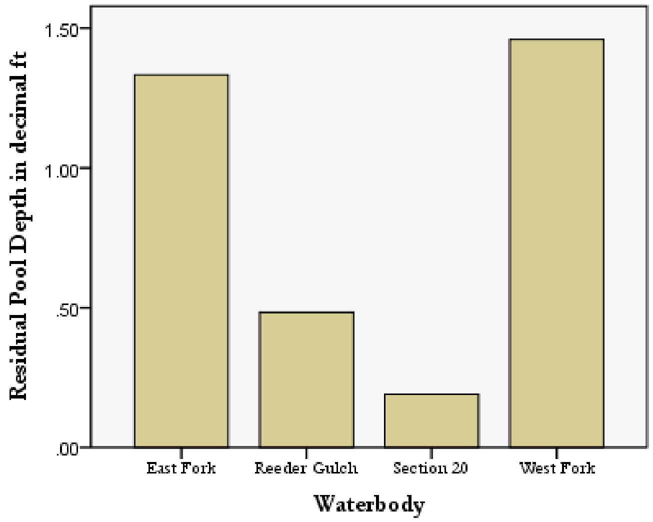

Figure 2 Displays the mean Residual Pool depth for all three years on each stream.

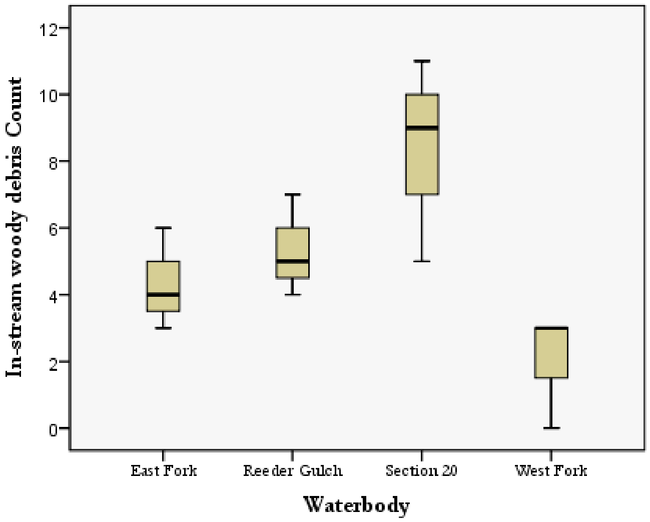

Figure 3 Box plots displaying counts of woody debris.

HBI values were significantly different across the reaches (P-value <0.05) (Table 5). A Tukey post hoc analysis revealed that those differences were among the East Fork and the West Fork. However, all the values across all the years and sites were low, which indicates the observed taxa from the samples have a high sensitivity, meaning those sites have low organic enrichment. Figure 4 shows the box plots for the values of HBI throughout all three years plotted for each site. Significant differences depicted from the statistical test were from East and West Fork, judging from the graph the differences are evident.

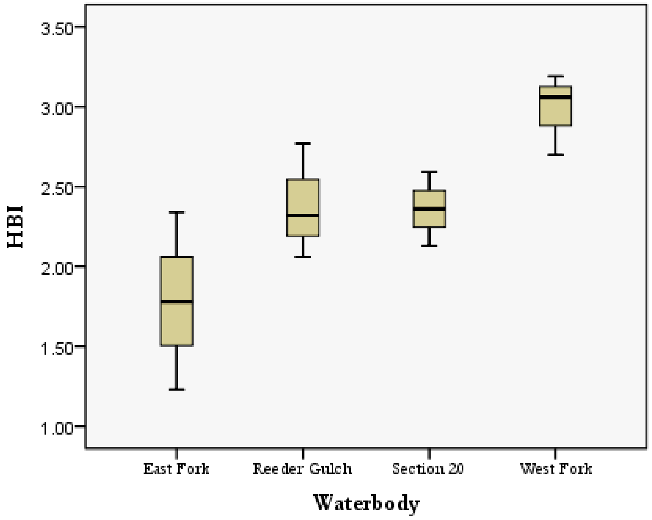

Figure 4 Box plots of the HilsenhoffBiotic Index for all three year (2010, 2011, and 2012) across all four streams.

Table 5 ANOVA table for Hilsenhof Biotic Index

Variable	Type of Test	F-Test	P-Value
HBI	ANOVA	5.198	<0.028

Results of the Level III assessment are displayed on Table 6 where East Fork exhibited no impairment indicating good diversity of invertebrates and stream conditions with little or no disturbance. For all three years East Fork had the same characteristic with no impairment. Reeder Gulch and South Section 20 exhibited slight impairment indicating some evidence of habitat stress exists. In 2010 and 2012 these streams scored a "slight impairment" value, however in between (2011) those years these sites exhibited no impairment (Table 6). Collection of more data would be wise to be able run further projection analysis of these bio assessments. West Fork exhibited the same structure as East, with no impairment indicating good diversity of invertebrates experiencing little or no disturbances.

Figure 5 shows the mean substrate particle count for each habitat across all years and across all sites. The mean substrate statistic can be used to track the potential for increased sediment loads during AFR treatment.

Table 6 Levels of Stream Impairment (No impairment, Slight impairment, Moderate impairment, Severe impairment) for 2010, 2011, and 2012 for the four streams. Level II assessment for 2010 and 2011 was conducted by Levi Drake, Ryan McKim, and Dr. Peter Schroeder (SOU, Department of Biology). I personally conducted the Level III assessment for 2012.

Year	**East Fork**	**Reeder Gulch**	**South Section 20**	**West Fork**
2010	None	Slight	Slight	None
2011	None	None	None	None
2012	None	Slight	Slight	None

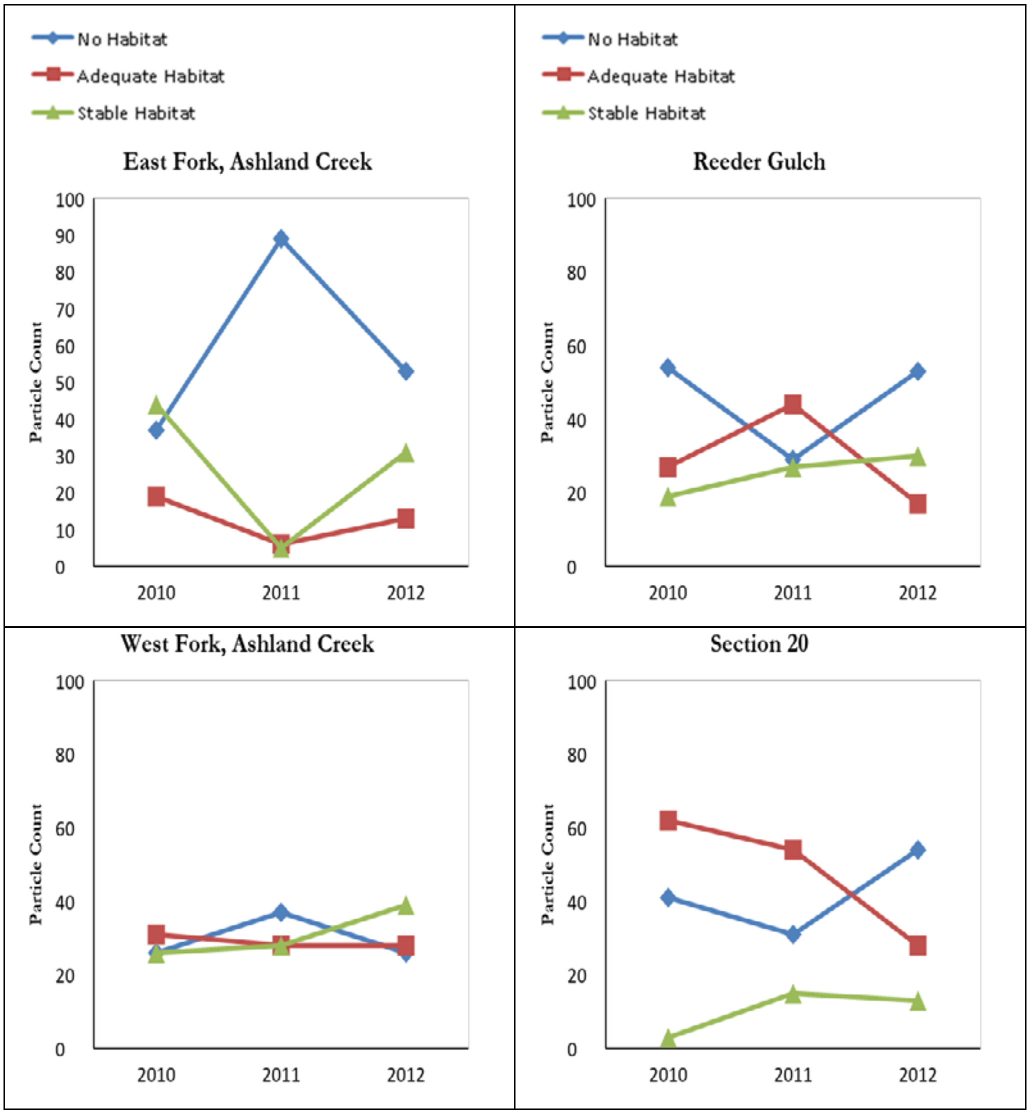

Figure 5 Depicts embedded substrate on tributaries of Ashland Creek from 2010-2012. Substrate classes are divided into three hyporheic zones: no habitat (substrate classes: sand < 2 mm, very fine gravel 2-4 mm, bedrock > 4096 mm), adequate habitat (substrate classes: fine gravel 4-8 mm, medium gravel 8-16 mm, coarse gravel 16-32 mm), and stable habitat (substrate classes: very coarse 32-64 mm, small cobble 64-128 mm, large cobble 128-256 mm, boulders 256-512 mm).

In Figure 6 the bar graph shows the values of the particle count for each site based on the Pebble counts explained in the methods. Interesting patterns reveal important indications of high and low sediment loads. East Fork sample sites had an accumulation of bedrock, which was categorized under no habitat. Perhaps the high counts of bedrock influenced the distribution of no habitat.

Averaged across all three years the particle count mean for no habitat substrate is 44.17, adequate habitat substrate is 29.75, and stable habitat substrate is 23.08. Meaning there are substrate classes (e.g. <2mm, >4096mm) that provide little to no habitat for macroinvertebrates. An analysis of variance for substrate found a significant difference between habitats (no, adequate, stable). In addition there is a significant interaction between each site and the habitat (Table 7) meaning the habitat at each site is dependent upon the characteristics found at each site. A Tukey post hoc analysis revealed that "No Habitat" differed among adequate and stable habitat.

This information is somewhat surprising but important to investigate for these are areas that need a closer look. The geomorphology of each plays an important role in providing substrate.

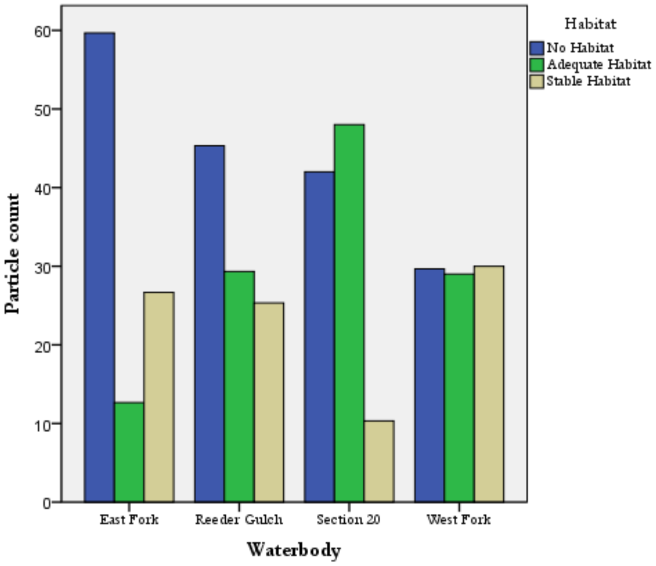

Figure 6 Displays the mean statistic on each substrate class (No habitat, Adequate habitat, and Stable habitat) averaged across all three years on the four streams

Table 7 Displays two-factor ANOVA tests results of between-subjects effects.

Variable	F-Test	P-Value
Waterbody	.173	>0.914
Habitat	7.72	<0.003
Waterbody*Habitat	3.54	<0.012

Conclusions:

Overall this research examined various parameters to assess and monitor stream conditions and macroinvertebrates, all of which are important in determining if a watershed is healthy. This research found that canopy closure showed no differences (df=3, P-value>0.25) among sites, therefore we can expect sparse canopy cover to not be an issue as a source of biotic stress. Large in-stream woody debris exhibited significant differences between South Section 20 and West Fork (df=3, P-value<0.033). Residual Pool depth showed differences among sites (df=3, P-value<0.00), but no significant difference between the East and West forks. Substrate revealed significant differences between habitats (no, adequate, stable). In addition there is a significant interaction between each site and the habitat, however not the year. The HBI differ between the East Fork and the West Fork (df=3, P-value<0.028).

Level III bio-assessment for 2012 has been conducted and should be implemented annually to assess trends across the years and the sites. Data collection had no replication at each which posed a limitation on statistical analyses. Therefore future monitoring implementations should be focused at methods where replication is performed. As a result further analysis can be conducted and annual reports can be distributed among stakeholders.

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